

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CIL HARDWARE

NUMBER: 03-1-0208 -X

SUBSYSTEM NAME:

REVISION: 2 07/26/00

PART DATA

PART NAME	PART NUMBER
VENDOR NAME	VENDOR NUMBER
LRU : LOW PRESSURE 2-WAY SOLENOID VALVE, NC	MC284-0403-0013/-0023
UNITED SPACE ALLIANCE - NSLD	12201-2/-3

EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:

VALVE, 2-WAY, DIRECT ACTING SOLENOID, ENGINE 2 HELIUM CROSSOVER VALVE (LV10), NORMALLY CLOSED (0.5" DIAMETER).

VALVE WAS ORIGINALLY DESIGNED AND MANUFACTURED BY WRIGHT COMPONENTS (NOW PERKIN ELMER) BUT IS NOW MANUFACTURED BY UNITED SPACE ALLIANCE-NSLD AS AN ALTERNATE PRODUCTION AGENCY.

REFERENCE DESIGNATORS: LV10

QUANTITY OF LIKE ITEMS: 1

FUNCTION:

ISOLATES THE HE SUPPLY DEDICATED TO ENGINE 2 FROM THE PNEUMATIC VALVE ACTUATION HELIUM SUPPLY. CROSSOVER VALVE IS NORMALLY OPENED AT MECO TO COMBINE RESIDUAL HELIUM FROM THE ENGINE 2 SUPPLY WITH THE PNEUMATIC VALVE ACTUATION HELIUM SUPPLY FOR MECO VALVE ACTUATION AND MPS PROPELLANT DUMP. IT IS ALSO OPEN DURING ENTRY (AT MAJOR MODE 303) TO SUPPORT AFT COMPARTMENT PURGE AND MPS SYSTEM REPRESSURIZATION.

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SUBSYSTEM NAME: MAIN PROPULSION

LRU: VALVE, SOLENOID, NC 2W

CRITICALITY OF THIS

ITEM NAME: ENGINE 2/PNEUMATIC CROSSOVER VALVE (LV10)

FAILURE MODE: 1/1

FAILURE MODE:

RUPTURE/LEAKAGE OF VALVE BODY.

MISSION PHASE:

- PL PRE-LAUNCH
- LO LIFT-OFF
- DO DE-ORBIT

VEHICLE/PAYLOAD/KIT EFFECTIVITY:

- 102 COLUMBIA
- 103 DISCOVERY
- 104 ATLANTIS
- 105 ENDEAVOUR

CAUSE:

MATERIAL DEFECT, FATIGUE, DAMAGED/DEFECTIVE SEAL.

CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

REDUNDANCY SCREEN

- A) N/A
- B) N/A
- C) N/A

PASS/FAIL RATIONALE:

A)

B)

C)

- FAILURE EFFECTS -

(A) SUBSYSTEM:

DURING ASCENT, THE ENGINE 2 AND/OR PNEUMATIC HELIUM SUPPLIES WILL BE LOST. ESCAPING HELIUM MAY OVERPRESSURIZE THE AFT COMPARTMENT.

DURING ENTRY, VENT DOORS ARE CLOSED TO PREVENT INGESTION OF RCS AND APU GASES. RUPTURE DURING THE TIME PERIOD THAT THE VENT DOORS ARE CLOSED MAY

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RESULT IN OVERPRESSURIZATION OF THE AFT COMPARTMENT. VENT DOORS ARE OPENED WHEN VEHICLE VELOCITY DROPS BELOW 2400 FT/SEC.

PRIOR TO T-9 MINUTES, EXCESSIVE HELIUM LEAKAGE WILL BE DETECTABLE USING HAZARDOUS GAS DETECTION SYSTEM (HGDS).

(B) INTERFACING SUBSYSTEM(S):
SAME AS A.

(C) MISSION:
POSSIBLE LAUNCH SCRUB DUE TO LCC VIOLATION.

(D) CREW, VEHICLE, AND ELEMENT(S):
POSSIBLE LOSS OF CREW/VEHICLE.

(E) FUNCTIONAL CRITICALITY EFFECTS:
NONE.

-DISPOSITION RATIONALE-

(A) DESIGN:
THE SOLENOID VALVE IS A NORMALLY CLOSED, DIRECT-ACTING VALVE. WHEN DEENERGIZED, THE VALVE POPPET IS HELD AGAINST THE VALVE SEAT BY A SPRING AND A BELLOWS, EITHER OF WHICH CAN MAINTAIN THE CLOSED POSITION. THE BELLOWS ASSEMBLY INTYERIOR IS EXPOSED TO OUTLET PRESSURE BY VENT HOLES THROUGH THE POPPET, PROVIDING A FORCE BALANCE WHICH ALLOWS THE SOLENOID, WHEN ENERGIZED, TO DEVELOP SUFFICIENT FORCE TO OPEN THE VALVE.

STRUCTURAL FAILURE OF THE BELLOWS (NOT BELLOWS LEAKAGE, BUT MAJOR STRUCTURAL LOSS) IN COMBINATION WITH EITHER THE LOSS OF THE POPPET-TO-PLUNGER PIN OR THE SPRING WOULD CAUSE VALVE FAILURE TO REMAIN CLOSED.

STRUCTURAL FAILURE OF THE PLUNGER, THE POPPET, THE BELLOWS ASSEMBLY, OR THE POPPET-TO-PLUNGER PIN CAN CAUSE VALVE FAILURE TO OPEN/REMAIN OPEN. THE 430 CRES PLUNGER, 304 CRES RETAINER AND POPPET, AND 17-4 PH HEAT TREATED CRES PIN TRANSFER ONLY THE LOAD OVERCOMING THE BELLOWS RESISTANCE (SPRING RATE OF 110 LB/INCH OVER A STROKE OF 0.060 INCH, OR 6.6 LB FORCE).

THE BELLOWS (P/N 24408-1 AND 24408-2) ARE MADE OF TWO NICKEL-COBALT-COPPER PLIES USING AN ELECTRO DEPOSITING PROCESS AND ARE ASSEMBLED INTO A SUB-ASSEMBLY. THIS SUB-ASSEMBLY IS PROOF PRESSURE TESTED AT 1550 PSIG AND LEAK CHECKED AT 850 PSID PRIOR TO VALVE FINAL ASSEMBLY. BELLOWS P/N 24408-1 ARE INSTALLED IN THE MC284-0403-0012 VALVE ASSEMBLY AND ARE CAPABLE OF 5,000

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PRESSURE CYCLES (LIMITED 35 MISSION CERTIFICATION). THE -0022 VALVE CONFIGURATION USES A BELLOWS P/N 24408-2 WHICH IS CAPABLE OF 20,000 PRESSURE CYCLES (100 MISSION CERTIFICATION).

WHEN THE VALVE IS IN THE CLOSED (DE ENERGIZED) POSITION, THE ONLY LOADS EXPERIENCED BY THE POPPET-TO-PLUNGER PIN ARE THOSE EXERTED BY THE SPRING (13.5 LB IN THE INSTALLED CONFIGURATION). THE PIN IS MADE OF 17-7 PH CRES, IS HEAT TREATED, AND HAS A 0.093 INCH DIAMETER.

THE SPRING IS FORMED FROM 0.035 INCH DIAMETER ELGILOY SPRING WIRE AND IS HEAT TREATED FOLLOWING FORMING. IT HAS A SPRING RATE OF 40 LB/INCH.

THE SOLENOID COIL IS HOUSED IN AN EB WELDED AND LEAK-TESTED CRES ASSEMBLY. THE COIL UTILIZES HIGH TEMPERATURE WIRE WOUND ON A CORE. AN ELECTRICAL CONNECTOR IS WELDED ON THE HOUSING. HIGH TEMPERATURE WIRES BETWEEN THE CONNECTOR AND THE COIL ARE SILVER SOLDERED AT THEIR CONNECTIONS. THE COMPLETE ASSEMBLY IS IMPREGNATED WITH EPOXY UNDER VACUUM CONDITIONS. THIS TYPE OF SOLENOID CONSTRUCTION HAS BEEN SUCCESSFULLY USE ON MANY PROGRAMS AND HAS BEEN SUBJECTED TO OVER 10,000 LIFE AND THERMAL QUALIFICATION CYCLES.

(B) TEST:
ATP

EXAMINATION OF PRODUCT

AMBIENT TEMPERATURE TESTS:

PROOF PRESSURE (1550 PSIG)
EXTERNAL LEAKAGE (850 PSIG)
INTERNAL LEAKAGE
(INLET-TO-OUTLET AT 825 PSID AND OUTLET-TO-INLET AT 150 PSID)
ELECTRICAL CHARACTERISTICS
(PULL-IN/DROPOUT VOLTAGE, CURRENT SIGNATURE AT 850 PSIG)
VALVE RESPONSE TIMES (850 PSIG)
REVERSE PRESSURE VALVE RESPONSE TIMES (150 PSIG)

REDUCED TEMPERATURE TESTS (-160 DEG F)

INTERNAL LEAKAGE
(INLET-TO-OUTLET AT 825 PSID AND OUTLET-TO-INLET AT 150 PSID)
ELECTRICAL CHARACTERISTICS (PULL-IN/DROPOUT VOLTAGE AT 850 PSIG)
VALVE RESPONSE TIMES (850 PSIG)
REVERSE PRESSURE VALVE RESPONSE TIMES (150 PSIG)

ELECTRICAL TESTS
ELECTRICAL BONDING
DIELECTRIC WITHSTANDING VOLTAGE
INSULATION RESISTANCE

CERTIFICATION

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PORT AND FITTING TORQUE (2 UNITS)
(TWICE NORMAL INSTALLATION TORQUE)

SALT FOG TEST (1 UNIT)
PER MIL-STD-810

SHOCK
PER MIL-STD-810
BENCH HANDLING
DESIGN

VIBRATION (2 UNITS)

TRANSIENT: 5 TO 35 HZ

RANDOM:
ONE UNIT TESTED ENERGIZED AND FLOWING 100 SCIM, SECOND UNIT TESTED
DEENERGIZED
INLET PRESSURE: 750 PSIG AMBIENT HELIUM
13.3 HOURS FOR EACH OF 2 AXES

PANEL MOUNTED (2 UNITS)
INLET PRESSURE: 750 PSIG AMBIENT HELIUM
13.3 HOURS FOR EACH OF 3 AXES

ELECTRICAL CHARACTERISTICS, VALVE RESPONSE, AND INTERNAL LEAKAGE AFTER EACH
AXIS

FLOW TEST

DIFFERENTIAL PRESSURE TEST (1 UNIT)
INLET PRESSURE: 525 PSIG AMBIENT HELIUM
FLOW RATES: 0.15 TO 0.25 LBS/SEC
PRESSURE DROP NOT TO EXCEED 125 PSID

HIGH FLOW CLOSURE TEST (1 UNIT)
3 CYCLES:
INLET PRESSURE: 850 PSIG AMBIENT HELIUM
FLOW RATE: 0.3 LB/SEC
CYCLE VALVE CLOSED AND VERIFY BY LEAKAGE TEST
CONTINUOUS CURRENT TEST (2 UNITS)

HOURS WITH SOLENOID ENERGIZED
+130 DEG F SURROUNDING ENVIRONMENT
INSULATION RESISTANCE TEST (+130 DEG F MAINTAINED)
RESISTANCE TEST (AMBIENT TEMPERATURE)
THERMAL VACUUM AND ENDURANCE TEST (2 UNITS)

CYCLES: 850 PSIG, AMBIENT HELIUM
500 CYCLES: 850 PSIG, +130 DEG F HELIUM

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500 CYCLES: 850 PSIG, -160 DEG F HELIUM

OPERATIONAL CYCLE TEST

3 CYCLES PERFORMED DURING EXPOSURE TO FOLLOWING CONDITIONS:

VALVE ENERGIZED/DEENERGIZED

INLET PRESSURE: 750 TO 200 PSIG

TEMPERATURE: +130 TO +250 DEG F HELIUM

SURROUNDING TEMPERATURE: AMBIENT TO +275 DEG F

SURROUNDING ENVIRONMENT: AMBIENT TO VACUUM

ELECTRICAL CHARACTERISTICS AND INTERNAL LEAKAGE AFTER EACH SET OF CYCLES AT APPROPRIATE TEMPERATURE CONDITIONS

BURST TEST (1 UNIT)

3400 PSIG

GROUND TURNAROUND TEST

ANY TURNAROUND CHECKOUT IS ACCOMPLISHED IN ACCORDANCE WITH OMRSD.

(C) INSPECTION:

RECEIVING INSPECTION

RAW MATERIALS ARE VERIFIED BY INSPECTION FOR MATERIAL AND PROCESSES

CERTIFICATION. BODY HOUSING BAR STOCK IS ULTRASONICALLY INSPECTED.

CONTAMINATION CONTROL

CLEANLINESS LEVEL IS VERIFIED TO 100A. CORROSION PROTECTION IS VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION

ALL DETAIL PARTS AND ASSEMBLIES ARE EXAMINED FOR BURRS, DAMAGE AND CORROSION (AT 10X MAGNIFICATION) AND INSPECTED FOR CORRECT DIMENSIONS PRIOR TO ASSEMBLY. CRITICAL SURFACE FINISHES ARE INSPECTED USING A COMPARATOR AT 10X MAGNIFICATION. OTHER SURFACE FINISHES ARE INSPECTED AND VERIFIED WITH A PROFILOMETER. TORQUES ARE VERIFIED TO BE IN ACCORDANCE WITH DRAWING REQUIREMENTS. BELLOWS ASSEMBLY IS PROOF PRESSURE TESTED AND LEAK CHECKED. MANDATORY INSPECTION POINTS ARE INCLUDED IN THE ASSEMBLY PROCEDURE.

CRITICAL PROCESS

THE FOLLOWING ARE VERIFIED BY INSPECTION:

WELDING

HEAT TREATMENT

PARTS PASSIVATION

POTTING OF SOLDER CUPS

ELECTRICAL WIRE STRIPPING

DRY FILM LUBRICATION

CHROME PLATING

NONDESTRUCTIVE EVALUATION

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ALL WELDS ARE VISUALLY EXAMINED AND VERIFIED BY X-RAY OR DYE PENETRANT INSPECTIONS. THE SOLENOID ASSEMBLY IS SUBJECTED TO LEAKAGE VERIFICATION USING RADIOACTIVE TRACER TECHNIQUES. SOME VALVE BODIES WERE SUBJECTED TO 10X MAGNIFICATION INSPECTION ONLY. OTHER VALVE BODIES WERE SUBJECTED TO EDDY CURRENT INSPECTION, IN ADDITION TO 10X MAGNIFICATION. REFURBISHED VALVE BODIES ARE SUBJECTED TO 40X MAGNIFICATION INSPECTION.

TESTING
ATP VERIFIED BY INSPECTION.

HANDLING/PACKAGING
HANDLING, PACKAGING, STORAGE AND SHIPPING REQUIREMENTS ARE VERIFIED BY INSPECTION.

(D) FAILURE HISTORY:

DURING QUALIFICATION, THE "V" SEAL WAS NOT SEALING PROPERLY (REFERENCE CAR A9476). THE THICKNESS OF SILVER PLATE WAS INCREASED TO 0.003 EFFECTIVE NEXT PRODUCTION ORDERS AND REPAIR.

DURING ATP, THE UNIT WAS FOUND TO BE LEAKING ACROSS A DAMAGED "V" SEAL (REFERENCE CAR AC5633). THE SEAL WAS REPLACED AND PERSONNEL WERE CAUTIONED TO USE UTMOST CARE DURING VALVE ASSEMBLY. INSPECTION PERSONNEL WERE INSTRUCTED TO PERFORM A COMPLETE PRETEST PRIOR TO ACCEPTANCE TESTING.

AT DOWNEY, THE "V" SEAL WAS MISSING (REFERENCE CAR AC7257). THIS WAS SCREENED DURING PANEL LEAK CHECK. THE ASSEMBLY PROCEDURE WAS CHANGED TO VERIFY "V" SEAL INSTALLATION.

AT DOWNEY TWO VALVES WERE FOUND WITH SAFETY WIRE MISSING FROM THE SOLENOID MOUNTING SCREWS (REFERENCE CARS AC6776, AC6777). SUPPLIER ADDED MANDATORY INSPECTION BUY-OFF TO ASCERTAIN THAT SAFETY WIRE IS INSTALLED.

CURRENT DATA ON TEST FAILURE, FLIGHT FAILURE, UNEXPLAINED ANOMALIES, AND OTHER FAILURES EXPERIENCED DURING GROUND PROCESSING ACTIVITY CAN BE FOUND IN THE PRACA DATABASE.

(E) OPERATIONAL USE:

PNEUMATIC BOTTLE PRESSURE IS ON DEDICATED DISPLAY IN THE COCKPIT. CREW WILL FOLLOW NORMAL ISOLATION PROCEDURE. THE PNEUMATIC SUPPLY WILL BE SAVED FOR REPRESSURIZING THE PNEUMATIC ACCUMULATOR IF NECESSARY AND ALSO AS ADDITIONAL ENGINE SUPPLY.

THE LEFT ENGINE HELIUM BOTTLE PRESSURE IS ALSO ON A DEDICATED DISPLAY IN THE COCKPIT. ATTEMPTS TO ISOLATE THE LEFT ENGINE HELIUM SYSTEM BY THE NORMAL CREW PROCEDURE WILL BE INEFFECTIVE DUE TO THE LEAK LOCATION.

- APPROVALS -

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S&R ENGINEERING	: W.P. MUSTY	:/S/ W. P. MUSTY
S&R ENGINEERING ITM	: P. A. STENGER-NGUYEN	:/S/ P. A. STENGER-NGUYEN
DESIGN ENGINEERING	: DAVE NEARY	:/S/ DAVE NEARY
MPS SUBSYSTEM MGR.	: TIM REITH	:/S/ TIM REITH
MOD	: JEFF MUSLER	:/S/ JEFF MUSLER
USA SAM	: MIKE SNYDER	:/S/ MIKE SNYDER
USA ORBITER ELEMENT	: SUZANNE LITTLE	:/S/ SUZANNE LITTLE
NASA SR&QA	: ERICH BASS	:/S/ ERICH BASS